



Accident Prevention by the United States Bureau of Mines

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SYSTEMATIC training of miners in matters relating to safety, through a central organisation for nation-wide service, is of comparatively recent inauguration in the United States, having been started slightly more than a decade ago. Under the conditions which existed prior to the establishment of the present system, each man was expected to look out for himself in meeting the hazards of his daily work. When disasters occurred, rescue work depended largely upon improvised measures. Only a few sporadic and widely separated efforts toward an organised system of training had been made.

If the industry had continued to employ the methods of production which characterised its early stages, when the mines were small and the workers highly intelligent and well trained in routine methods, the present system might never have proved necessary. But, with the growing demand for coal, and the attendant speeding up of mining, the units of production were enlarged greatly and the output began to assume tremendous proportions. The increase in production was not accompanied, however, by a proportionate increase in the number of men employed. The greatly increased output of mines, those of coal in particular, has been secured in recent years by substantially the same number of miners as a decade or so ago, and with a personnel not nearly so well trained. The production of coal in 1918, a record year due to war-time demands, was 41 per cent. greater than in 1907, yet there were only 12 per cent. more men engaged in coal mining in 1918 than in 1907. Necessarily, in the period of war-time demand, the number of days actually worked per year was larger than in peace time, but the actual

number of men engaged in the industry during the war years was not greatly in excess of the number employed previously and was less than the number employed annually since the war. Clearly the output of each miner has increased. Considering only the men employed underground, the production per miner per year has increased from 852 tons in 1907 to 1,134 in 1918, and the daily production from 3.69 tons in 1907 to 4.40 tons in 1918. This increase, however, is not equally noticeable when the total number of miners employed underground and aboveground is considered. The percentage of coal mined by machinery during the same period has increased from 35.1 in 1907 to 55.9 per cent. in 1918.

This speeding up of the industry, the change in the character of mine labour and mining methods, and the increasing hazard resulting from enlarged production began to attract national attention in the years immediately preceding the establishment of the Bureau of Mines. It was evident to all far-seeing executives of the industry that more care must be devoted to avoiding accidents and more elaborate preparations made for meeting them when they did occur. With a characteristic keenness of vision, Dr. Joseph A. Holmes, then head of the technological branch of the United States Geological Survey and afterwards first Director of the Bureau of Mines, devoted his energies to the creation of a Federal agency to be charged with the duty of investigating causes of mine accidents, reducing their number, and lessening the severity of those which would continue to occur. Public attention was focussed sharply on this need by a series of particularly disastrous coal mine explosions in 1907 and Congressional action resulted in the establishment in 1910 of a United States Bureau of Mines.

This Bureau has recently completed its first decade and it is interesting as well as instructive to review the results accomplished during this period. For these results, which indicate a rather definite decrease in the number of accidents and their toll in deaths and injuries, the Bureau of Mines by no means claims entire credit. A most important factor has been the hearty co-operation of the miners, mine owners, government officials, and mining associations. All have worked together to make mining safer. Fatal accidents at coal mines and metal mines during this period show a decreasing trend, especially when considered in connection with the increased output of mines, and the number of persons employed. The following table shows the annual fatality rates in each of the two classes of mines, and for both classes combined (1).

(1) *Editorial Note.* In the January number of the *International Labour Review* (Vol. V, No. 1, pp. 139-144) a comparison was made of coal mine fatalities in the United States and the United Kingdom.

TABLE I. FATAL ACCIDENT RATE PER 1,000 THEORETICAL 300-DAY WORKERS EMPLOYED IN MINES IN THE UNITED STATES

Year	Numbers killed per 1,000 theoretical 300-day workers		
	Coal mines	Metal mines	Both combined
1911	4.97	4.45	4.86
1912	4.46	4.09	4.38
1913	4.70	3.72	4.46
1914	4.66	3.92	4.50
1915	4.44	3.89	4.32
1916	3.93	3.62	3.86
1917 ⁽¹⁾	4.25	4.44	4.29
1918	3.94	3.57	3.86
1919	4.27	3.47	4.11
1920 ⁽²⁾	3.61	3.16	3.53
1921 ⁽²⁾	4.06	—	—

(1) The year 1917 was one of increasing production and labour scarcity, resulting in bringing into the mines a large number of new workers not accustomed to the dangers of the work.

(2) Preliminary estimates.

The number of miners trained and re-trained by the Bureau has been increasing rapidly. In its first year the Bureau of Mines trained 734 men in mine rescue and first-aid methods. During the fiscal year ending 30 June 1921 the number trained was 10,720, in addition to which 1,805 received "additional" or advanced training. The number trained in 1917 happened to be particularly low, as the rescue cars of the Bureau spent several months in the repair shops and most of the training was by detached instructors. During the period in which the Bureau has been giving training, 61,691 persons have received first-aid or mine rescue certificates; 4,319 have received certificates of additional training, and more than a million individuals have either visited one of the mine rescue cars and stations or attended lectures given by the Bureau's staff.

TABLE II. STATEMENT OF TRAINING IN MINE-ACCIDENT PREVENTION BY THE UNITED STATES BUREAU OF MINES

Year	Number trained	Number receiving additional training	Number of visitors	Attendance at lectures
1911	734	—	72,050	71,444
1912	946	—	63,631	36,443
1913	2,014	—	46,105	32,866
1914	3,403	—	37,289	18,854
1915	4,258	—	60,124	53,612
1916	8,493	—	62,693	43,060
1917	4,828	—	36,211	39,258
1918	8,369	482	36,274	33,629
1919	8,933	848	58,135	82,086
1920	8,993	1,184	28,586	40,516
1921	10,720	1,805	44,479	59,334

The safety work of the Bureau of Mines is divided into two broad fields; first, investigation into causes of accidents and, second, instruction in first-aid and mine rescue work. The Bureau's research into conditions which result in accidents includes the development of devices and methods of production which will decrease the occurrence of accidents.

In the development of devices, noteworthy work has been accomplished in the Bureau's studies of electricity in mines. Electrical apparatus has become essential to the mining industry, but this apparatus must be made safe to use in explosive mixtures of methane and air. Investigators early recognised the danger which lurked in storage-battery locomotives, in electrically-operated coal-cutting machines, in electric switches, and in miners' electric lamps. Following various conferences, in which the different conditions and types of machines were discussed, the Bureau of Mines began conducting experiments and tests at its Pittsburgh station. The engineers have formulated certain tests which electrical equipment must meet if it may be used with safety in gaseous atmospheres. Equipment which has passed these "permissibility" tests of the Bureau of Mines successfully may be marked with an official stamp of approval, and is so known to have passed the Federal inspection and tests. As a practical matter machinery so approved finds a much more ready sale in the mines. This Federal approval system has resulted in the development of electrical devices to a point which probably would not have been achieved otherwise. The Federal Government, in this work, has received splendid co-operation from the manufacturers of electrical equipment.

Similarly the Bureau also introduced the system of "permissible" explosives, encouraging the use in coal mines of short, quick-acting flame powder instead of black blasting powder with its long flame and slow action. Certain standards have been set which an explosive must meet before it may be classed as "permissible". One of these is that it will not ignite an atmosphere which contains eight per cent. of gas. The use of permissible explosives in mines is on a constant increase, and there has been a consistent decrease in accidents due to explosions, since they became widely available.

There have also been studies of mine ventilation, of the explosibility of coal dust, of accidents from the fall of roofs, and of automatic rock-dust barriers to limit explosions. All these have received careful study by that part of the staff of the Bureau who deal with the conditions and causes of accidents and their prevention. In this work especially the experience of similar organisations in Europe has been drawn upon freely and visits and exchanges of information between the American and European staffs are regular features of the work. The American engineers are greatly indebted to their European colleagues and were especially helped at the beginning, since the United States

in this case followed rather than pioneered in taking up these studies.

The second phase of the safety work of the Bureau deals with research and instruction in first-aid and mine rescue methods, including the use of oxygen-breathing apparatus. This work is in the nature both of educational work and of scientific research. Except for the mines which are being operated on leased government lands, the Federal Government is not empowered to enact or enforce safety codes or operating regulations. Inspection of mines is strictly within the authority of the State Governments. It is the function of the Federal Government to make the studies and develop the facts on which good inspection laws and rules may be framed and to instruct miners and others in safe methods of work.

As a part of its educational work the Bureau of Mines has been issuing "Miners' Circulars", which tell of the dangers in mines and the precautions a man should take to avoid injuries and disease. Other publications dealing with safety are also issued. It was felt by the Bureau, however, that proper dissemination of necessary information could not be obtained by the mere issue of publications. There was established, therefore, a system of mine rescue cars and trucks, operated by a personnel trained in mine rescue and first-aid methods. The mining regions of the country were grouped within nine districts, the division having been made with special reference to the rendering of the most speedy service possible by either cars or station personnel in the event of disaster. The work in each section is under the direction of a district engineer, whose work is under the supervision of the chief of the Bureau's Mine Safety Service, with offices at Pittsburgh, Pennsylvania. The Bureau's equipment consists of ten mine rescue railroad cars, ten safety stations, and a number of two-ton and half-ton motor trucks. Itineraries for each car are arranged within its district providing for travel from one mine to another. The engineer organizes classes among the employees of each mine and instructs them in first-aid and mine rescue work. In the event of a mine accident, the nearest mine rescue car is sent immediately to the scene on the first available train or by special locomotive. Each car and each motor truck is equipped with oxygen-breathing apparatus, tanks of oxygen, first-aid material, and fire-fighting apparatus. The personnel attached to each car consists of a car engineer, car surgeon, foreman miner, first-aid miner, clerk, and cook. It is a general rule that the foreman miner, first-aid miner, clerk, and cook live on the car, while the engineer and surgeon are available immediately in the event of an emergency.

Upon the completion of the specified course in first-aid, mine rescues, or the combined training, the miner is given a diploma and certificate. Persons who receive certificates of first-aid training are instructed and examined in the anatomy of the

human body, the treatment of haemorrhage, fractures, burns and shock, and the transport of wounded persons. Certificates of rescue training are given to persons who pass a physical examination for fitness for rescue work, wear breathing apparatus while doing hard labour in atmospheres containing noxious or irrespirable gases, and demonstrate their ability to adjust and take care of such apparatus and to perform the duties of rescue men. The training given represents fifteen hours of intensive work. Extra certificates are given upon the completion of the additional training course.

An important duty of the staff in this division is to inspect rescue apparatus owned by mining companies, when requested by the companies concerned, and to give advice, when desired, as to the condition of the apparatus and the repairs needed. Such inspection is important because rescue apparatus and parts are particularly subject to deterioration. Unless the apparatus is in proper condition, the lives of the wearers are imperilled. The Bureau is also deeply concerned in physiological studies of the effects of mine gases, of dust, moisture, and temperature on underground workers, in the health conditions and sanitation of underground workings, of mining and metallurgical plants, and of mine villages, and in the development of new and better types of rescue apparatus.

In its mine accident statistical work the Bureau is not satisfied with routine compilation of numerical information, but aims at providing the Bureau's mining engineers with detailed information relating to the causes and frequency of accidents in the various mining districts. Mining conditions vary greatly, and it is only by supplying interpreted statistics relating to individual districts that it will be possible to determine the safety elements of the methods recommended for each.

The Bureau's accident statistics are based upon voluntary reports, there being no Federal law compelling returns. At the close of each calendar year blank questionnaires are mailed to operators of metal mines, quarries, coke ovens, and metallurgical plants, in all States except California and Utah, where the operators report directly to the State officials, who in turn compile the data and send the information to the Bureau. Statistics for coal mines refer to fatalities only and are reported monthly by State coal mine inspectors on forms supplied by the Bureau. The accident report cards, except those for coal mines, call for data showing the causes of accidents; whether the accident resulted in death, permanent total or permanent partial disability, temporary serious or temporary slight injury; average number of men employed; number of full days mine or plant was operated; kind of mineral, metal, or stone produced and, for mines, the method of mining. For coal mines, data as to the number of employees are obtained annually from the United States Geological Survey, which organisation was collecting such data before the Bureau of Mines was set up.

In calculating the average number of employees, the operators have been asked to divide the total number of shifts worked by the number of full days the plant was in operation, the quotient representing the average number of workers, office employees being excluded. All statistical data are for calendar years. Separate reports are issued annually covering accidents at coal mines, metal mines, quarries, coke ovens, and metallurgical plants. The issue of separate reports effects economy in distribution, as each industry is generally interested only in the reports which relate to it.

When the statistical work of the Bureau was begun, it had been the practice of State mining Departments to publish accident rates based upon the number of employees regardless of the period of exposure to risk. The Bureau of Mines followed this practice for several years and then changed to a uniform number of shifts worked. The basis used was 300 shifts per man per year and accident rates were shown for each thousand of these theoretical 300-day workers. Should the returns for 1921 permit, it is hoped to calculate accident rates on the basis of a year consisting of 300 days of a uniform number of working hours, that is, hours of exposure to accident risks.

The Bureau of Mines holds that the training of miners to increase safety is an obligation which the mine operators and State Governments share with the Federal Government and every effort is made to induce them to share in the work. Considerable advance has been made in this direction. Larger mining companies, and in some cases groups of mining companies, have organized their employees in safety associations or taken other measures. The Montana Mine Safety and First Aid Society of Butte, Montana, has a membership of three hundred. A Miners' Field Day, including as its main features a miners' first-aid contest with approximately fifty contesting teams is held annually. Attendance at this field day has never been less than 18,000. The Anaconda Copper Mining Company and other Butte mining companies spend much time and money in making this field day a success. The Globe-Miami District Mine Rescue and First Aid Association typifies another type of safety organization. It consists of seven large metal mining and metallurgical companies. The Association is in charge of a director, assisted by three station attendants. A rescue station and rescue truck are maintained for emergency services to the Association members. The director arranges for first-aid and mine rescue training of miners and grants the association button for competency in first-aid work. Sixty of the employees trained in mine rescue are paid 25 cents a day bonus and are subject to call, with consequent double pay during such service, to any mine in the district in case of disaster. They receive an average of four hours' rescue training every six weeks.

Similar safety organisations, including the miner to a greater or less extent, are maintained by other mining companies and State mining Departments. Examples are the State rescue stations of Illinois and West Virginia, the Knox County Operators' Association of Bicknell, Indiana, and the Orient Rescue Station at Orient, Pennsylvania. One large mining company operating in West Virginia has through its safety organisation so interested its employees that 68 per cent. are trained in first-aid to the injured. On the whole the Bureau engineers feel that interest in safety is steadily growing throughout the mining industry of the United States.

